

Gas-Cluster Ion-Beam Manufacturing Tool for Next-Generation Semiconductor Devices

Microelectronics Manufacturing Infrastructure

ATP Project Number: 70NANB8H4011

Project Start/End Dates: Oct 1998 - Oct 2001

ATP Project Manager: Purabi Mazumdar

Principal Investigator: David B. Fenner

E P I O N Corporation, Billerica, Massachusetts

Company Overview

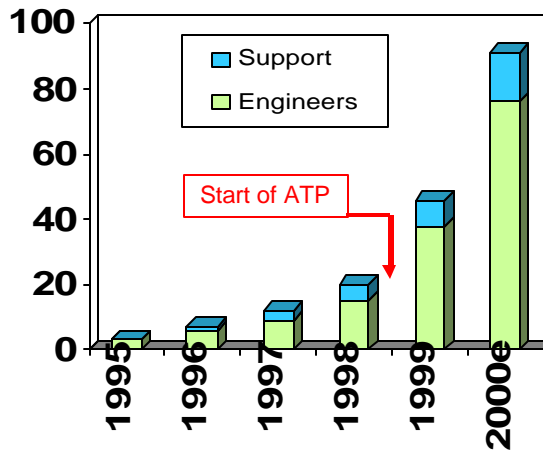
Founded to develop ion beam and laser beam technology for surface processing



37 Manning Road, Billerica, Massachusetts
www.epion.com

- Products :
 - > Gas-Cluster Ion-Beam Smoother
 - > Pulsed-Laser Deposition
 - > Coating & Implant Services
- Revenue :
 - > 1999 \$ 4 M (est.)
 - > 2000 \$12 M (est.)
- 23,000 ft² facility with capacity to manufacture > \$50 M/yr
- Presently 46 employees
- Located in world-center of ion-beam design & manuf.
- Active funded R&D \$1 M/yr

Staff Employees

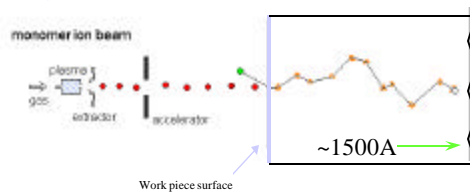


- Founded in 1984.
- Engineering team hired in 1998-'99.
- Key managers experienced in ion-beam design, manufacturing and processes.
- Grew from facilities of 11,500 sq-ft into 23,000 sq-ft in '99.

Ion-Beam Processing



◆ Conventional Ions



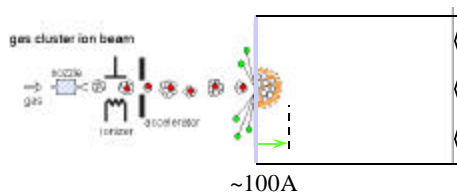
Widely used for:

- semiconductor devices
- photonics
- optical coatings

Equipment market: \$3 billion.

Ion-mixing limitations are severe for smaller devices.

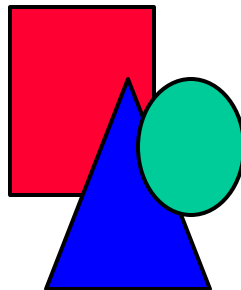
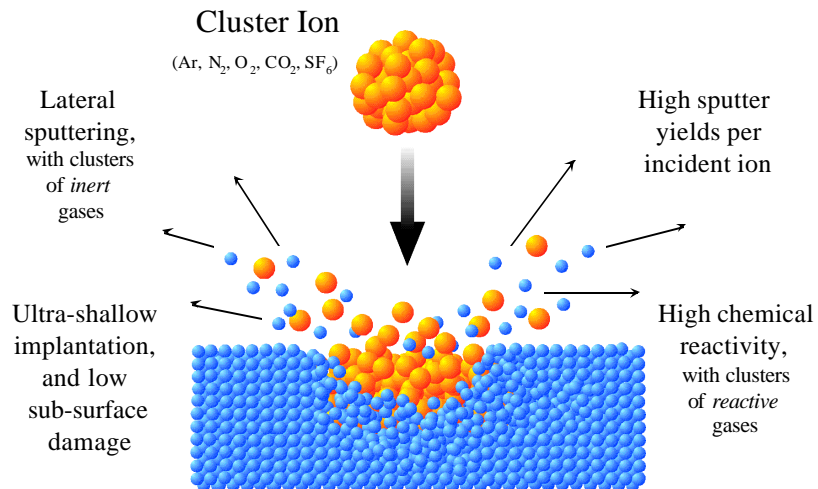
◆ Gas-Cluster Ions



Atomic-scale surface processing, without subsurface damage.

Not subject to limitations of conventional ions.

Retains the advantages of high-vacuum methods.



Specifications

- Fab-line compatibility cluster-tool (SEMI/MESC)
- Wafer robot and 5 w/hr throughput smoothing
- Argon gas-cluster ion-beam current 50 μ A.
- Electrostatic scan 6" wafers
- System control software.

Potential Applications for GCIB



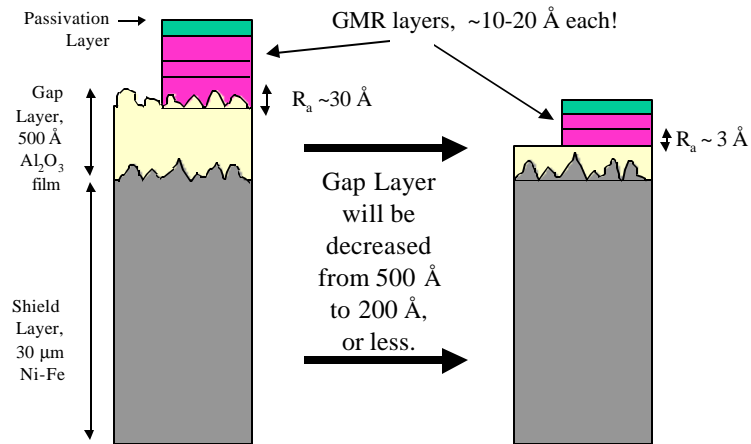
- ◆ Atomic-Scale **Smoothing**, Planarization and Cleaning
 - Surfaces of all microelectronic materials, especially thin films.
 - Final touch polish after chemical-mechanical polish (CMP).
- ◆ Sputter Etching
 - Spot-addressable thickness trimming of films and patterns.
 - Analytical instrumentation (high-resolution depth profiling in SIMS).
- ◆ Reactive Deposition, especially at lower temperature
 - Multiple-layer compound material films (Si_3N_4 , GaN).
 - Transparent electrically conductive films (ITO).
- ◆ Micromachining (MEMS)
 - Surface smoothing before wafer bonding in device fabrication.
- ◆ Ultra-Shallow Ion Implantation for MOSFET Fabrication
 - Decaborane implantation for source-drain extensions.

Smoothing Applications for GCIB



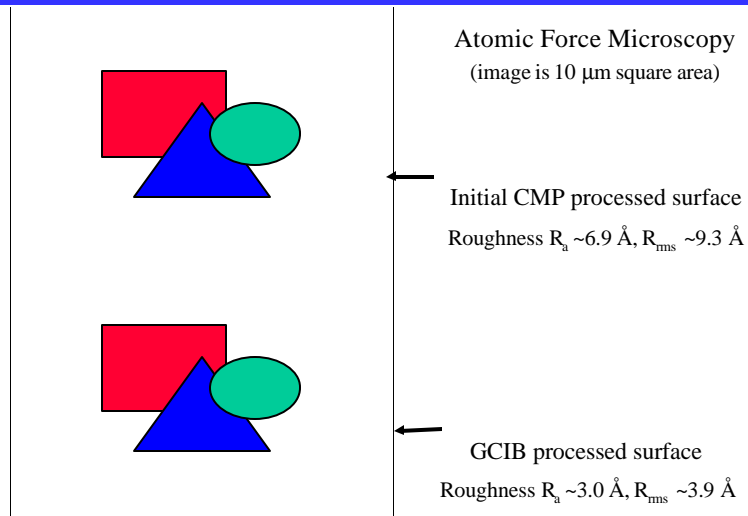
- ◆ Hard-disk (GMR) Magnetic Sensors
 - Dielectric gap layer, e.g., alumina and silica.
 - Magnetic shield layer, e.g., permalloy Ni-Fe.
 - Passivation layer, e.g., Ta.
 - Pole-tip cleaning after dicing of devices.
- ◆ Optics and Photonics
 - Mirror and lens, e.g., nickel-coated and diamond-turned mirror.
 - Fiber-optic filters, waveguides, and microlens, e.g. polysilicon.
- ◆ Semiconductors
 - High- κ dielectrics, e.g., Si_3N_4 and Ta_2O_5 and BaSrTiO_3
 - Floating gate metals.
 - Silicon-on-Insulator (SOI), e.g. SIMOX and BESOI, and ultra-thin Si on compliant-substrate SOI.

GMR Device Size Scaling

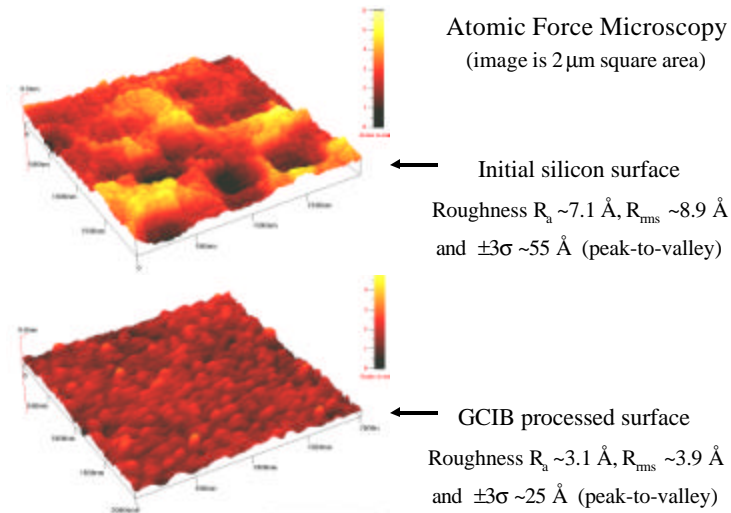


Surface roughness must be eliminated!

Permalloy (Ni-Fe) Thin Film



SIMOX-SOI Silicon Wafer



Tantalum Thin Film

